

Research on Optimal Dispatching of Renewable Energy and Traditional Power System

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Abstract: This research seeks to determine the most efficient method of incorporating renewable energy into the traditional power system. By analyzing the challenges and obstacles faced in merging renewable energy with the traditional power system, this study outlines the major variations in energy sources, the volatility of renewable energy, the uncertainty caused by climate change and weather patterns, the impact of renewable energy on grid stability. The power system's capacity and dependability were also taken into account. This study presents recommended scheduling suggestions to tackle these issues, encompassing intelligent energy prediction and management, incorporation of different energy storage technologies, enhancements to the distributed energy system, and utilization of smart grid technology.

Keywords: Renewable Energy; Traditional Power System; Power System Integration; Power System Optimization Dispatching.

1. Introduction

Widely promoted and concerned, renewable energy (RE) has been embraced globally as a clean and sustainable form of energy. However, compared with traditional fossil fuel power generation, renewable energy is characterized by volatility, intermittently and uncertainty. The volatility of renewable energy sources such as solar and wind power is impacted by factors such as day, night, season, and weather, leading to an unsteady energy supply and posing difficulties to the power system's steadiness and dependability. To better integrate and exploit renewable energy, it is very urgent to find a more efficient optimal dispatching method, so that renewable energy and traditional power system can be more closely integrated.

2. The dilemma and difficulty of the integration of renewable energy and traditional power system

2.1. Diversity and pressure of energy sources

The main challenge in integrating renewable energy and traditional power systems is the wide variety of energy sources available. Solar energy, wind energy, and water energy are the primary renewable sources, known for their environmental benefits and renewable nature. However, their instability and intermittent nature present obstacles to ensuring a consistent energy supply. Solar energy, for instance, is extensively utilized as a renewable source, as it converts sunlight into electricity using photovoltaic technology. However, because of day and night and weather changes, effective energy storage systems are needed to balance the fluctuations in energy demand. Wind turbines are used to convert the kinetic energy of the wind into electricity, making wind energy a widely used and renewable energy source. However, sudden changes in wind speed and extreme weather conditions can lead to fluctuations in power generation, requiring intelligent dispatching systems to maintain a stable supply of the power system. Water energy includes hydroelectric power and tidal power generation, which generate electric energy driven by water flow or tidal

fluctuations, and are relatively stable. However, in practical applications, the impact on the water ecological environment needs to be considered to ensure sustainable development. Traditional power systems rely mainly on fossil fuels and nuclear power generation. Fossil fuel power generation generates electricity through the burning of resources such as coal, oil and natural gas, but this way not only emits large amounts of carbon dioxide and other pollutants, but also causes resource depletion. Nuclear power generation is the use of nuclear fission reaction to release energy, but nuclear radiation and nuclear waste treatment are long-term problems, bringing environmental and safety risks. The unsustainability and environmental impact of traditional power systems have forced people to accelerate the shift to renewable energy, but the diversity of energy sources also makes it more difficult to dispatch systems and balance energy supply. Consequently, finding a solution to effectively integrate renewable energy with traditional power systems in the face of diverse energy sources is an urgent and crucial challenge within the current energy sector[1].

2.2. Instability and uncertainty

2.2.1. Volatility of renewable energy sources

In a brief span of time, the fluctuation in energy sources such as solar and wind power is described as the volatility of renewable energy. Solar energy changes throughout the day, affected by night, cloudy days and cloud cover, resulting in significant fluctuations in electricity generation. Similarly, wind energy is affected by wind speed, wind direction and other factors, and the change of wind energy also directly affects the efficiency of wind power generation. According to the International Energy Agency, global volatility in solar and wind power generation can reach more than 30 percent a year, which means that the supply capacity of renewable energy is likely to fall sharply in a short period of time. In addition, the seasonal changes in different regions have also affected the renewable energy supply. For example, in some areas, summer sunlight is strong and solar power is more efficient, but in winter, sunlight is weaker and power generation efficiency decreases. Wind may vary widely between seasons, making energy systems need to be able to adapt to these

seasonal changes.

2.2.2. Uncertainty in climate change and weather conditions

The growing recognition of climate change is progressively revealing its lasting effect on renewable energy. Changes in temperatures and the increase in extreme weather events may not only affect the efficiency of solar and wind power generation, but may also cause damage to energy facilities. For example, rising temperatures may cause lines in the power system to overheat, reduce transmission efficiency, and even cause equipment damage. In addition, extreme weather conditions such as hurricanes and droughts can also cause uncertainty in renewable energy systems. Hurricanes could damage wind turbines, and drought could cause less water for hydropower, affecting capacity. These uncertainties pose challenges to the stability and reliability of renewable energy systems.

2.3. Safety and stability of the power grid

2.3.1. Challenges of renewable energy to power grid stability

The swift expansion of renewable energy sources has posed unparalleled challenges to the power system. The integration of such large-scale renewable energy has had a tremendous effect on power networks. The International Energy Agency forecasts that by 2030, renewable energy will constitute more than 33% of the world's electricity production. This means that the power system must adapt to the increasing amount of renewable energy, while traditional power systems face key bottlenecks such as frequency regulation and voltage stability in the context of a high proportion of renewable energy. Significant difficulties in controlling the frequency of power systems arise from the incorporation of extensive renewable energy. The volatility of renewable energy sources easily impacts the frequency, which can result in deviation from the standard value and pose a risk of system collapse. At the same time, the voltage stability of the power system in a high proportion of renewable energy situation is also concerned. Unstable voltage may lead to equipment damage, and even cause fire and other safety hazards [2].

2.3.2. Capacity and reliability of the power system

Capacity limits in power systems have become particularly prominent when the supply of renewable energy fluctuates. When the supply of renewable energy increases dramatically, the power system needs to have enough capacity to meet peak demand to avoid power shortages. In addition, the reliability challenges of power systems are mainly reflected in the aging and maintenance needs of power equipment. With the gradual aging of the power equipment, the failure rate of the equipment increases, and the maintenance and replacement costs also increase. This makes it even harder to maintain the reliability of the power system.

3. Optimized dispatching strategy of integrating renewable energy with traditional power system

3.1. Intelligent energy prediction and management

3.1.1. Introduce advanced prediction technology

The prediction of renewable energy sources is being revolutionized by the rapid progress of machine learning and artificial intelligence. The meteorological model based on big

data uses historical meteorological data and other related data to accurately predict the future meteorological conditions, including wind speed, sunlight intensity, etc., to improve the accuracy of solar and wind power generation. The deep learning algorithm can automatically learn and adjust the model, and gradually improve the prediction accuracy. The utilization of these technologies has significantly enhanced the precision in forecasting data, demonstrating that the incorporation of machine learning algorithms has resulted in a 30 percent boost in accuracy for predicting solar power generation and a 25 percent increase for wind power generation. This not only means that the power system is more reliable, but also reduces the economic loss caused by excessive power generation or insufficient power supply, providing a strong support for the stability and economy of the energy system.

3.1.2. The intelligent energy management system's design and implementation.

The intelligent energy management system is a platform that utilizes data analysis and intelligent algorithms for efficient power system management. Its core architecture includes real-time data analysis, demand response, and adaptive control. Big data technology is utilized in real-time data analysis to gather, handle, and examine real-time data pertaining to energy production and consumption. This real-time monitoring system driven by data enables energy managers to gain precise insights into the status of energy production and consumption, enabling them to make precise and focused modifications. Demand response system can adjust the energy supply according to real-time demand to ensure the efficient use of energy. Intelligent algorithms are employed by the adaptive control system to adjust the energy system's operating parameters in response to real-time data, thereby allowing it to be more flexible and responsive to external environmental changes. In practical applications, the intelligent energy management system has been widely used in many countries. For example, in Germany, a large solar power station has introduced an intelligent energy management system, which enables the collaborative optimization of solar power generation, energy storage and power supply, and improves the energy efficiency. Similarly, some wind farms in the United States use smart energy management systems that use real-time data analysis to adjust the speed of wind turbines so that they can generate electricity efficiently at different wind speeds. The integration of renewable energy with traditional power systems is strongly supported by the remarkable effect smart energy management systems have had in enhancing energy utilization and decreasing carbon emissions, as evidenced by these cases[3].

3.2. Integration of multiple energy storage technologies

3.2.1. Different types of energy storage technologies

(1) Battery energy storage technology. Battery energy storage technology is one of the most widely used energy storage methods. Lithium-ion batteries, renowned for their high energy density, extended life and efficiency, are widely employed in mobile devices and electric vehicles. Additionally, sodium-sulfur batteries, with their higher energy density, are often utilized in large-scale energy storage systems, particularly grid-scale energy storage.

Compressed air energy storage technology involves the compression and storage of air in gas tanks, which is then released, when necessary, thus powering a turbine generator

to generate electricity. This technology has two major benefits: the low construction and maintenance costs, as well as its extended lifespan. It is competitive in scenarios with large energy storage capacity.

3.2.2. Advantages and applications of energy storage system

(1) Advantages of energy storage system in peak regulation. The energy storage system has the rapid response ability, can release the stored electricity during peak demand, balance the supply and demand, and avoid the power shortage caused by traditional power systems during peak hours. According to the U. S. Energy Information Administration, energy storage systems usually peak load for more than 20 percent of electricity, significantly reducing electricity prices during peak periods.

(2) Application of energy storage system in smooth fluctuation. The volatility of renewable energy makes the power system face frequent fluctuations. Energy storage systems can store excess electricity when solar or wind energy fluctuate and release it when needed, achieving smooth power output. A demonstration project in Germany shows that the application of energy storage systems has reduced the volatility of renewable energy by more than 60 percent, making the grid load curve smoother and improving the stability of the power system.

(3) The advantages of energy storage system in dealing with sudden loads. When faced with an abrupt increase in demand, the energy storage system is capable of promptly discharging the stored electric energy to fulfill the immediate high load requirement and avert system failure due to excessive demand. An example of this is the energy storage project in Japan, which has been instrumental in providing stability to the local power system during times of emergency, such as earthquakes.

(4) Energy loss and optimization strategy. There are energy conversion losses in the process of energy storage and energy release, such as resistance loss in the process of battery charging and discharging, and heat loss in compressed air energy storage. Optimisation strategies often include improving the efficiency of energy storage devices, choosing appropriate charge and discharge strategies, and the use of advanced battery management systems to reduce these losses. Through these optimization measures, the efficiency of energy storage systems can be improved to achieve more sustainable energy utilization [4].

3.3. Optimize the distributed energy system

3.3.1. Concept and working principle of distributed energy system

A distributed energy system is a system that distributes energy generation, storage, and use in different locations. It consists of distributed power generation, energy storage and energy use. Electricity is generated locally through the use of solar photovoltaic and wind power generation in distributed power systems. Excess electrical energy is stored in energy storage systems for future use. And then the energy end is the ultimate consumer of electricity, which can be domestic, industrial or commercial facilities. The flexibility and robustness of the distributed energy system make it have unique advantages in the power system. Different from the traditional centralized power generation system, the distributed energy system insthe energy generation point near the power site, which reduces the transmission distance and reduces the transmission loss. Adapting to local

meteorological shifts and electricity demand fluctuations, the system can be improved in stability and reliability while concurrently.

3.3.2. Optimize the scheduling algorithm and analysis

In distributed energy systems, collaborative optimization of scheduling algorithms is key. It enables efficient collaboration between distributed generation, energy storage and energy use. For example, in sunny weather, when solar power capacity increases, the system can automatically store excess electricity for use on night or cloudy days. This collaborative optimization strategy enables the system to achieve flexible scheduling under different meteorological conditions to maximize renewable energy utilization. In addition, it is also very important for distributed energy systems to adopt intelligent response strategies in the face of meteorological changes and electricity demand fluctuations. By monitoring meteorological data in real time, the system can predict weather changes in advance and make corresponding adjustments. At the same time, according to the users' electricity habits and demand, a reasonable electricity consumption plan is formulated to ensure the stability of power supply. According to the U. S. Energy Information Administration, collaborative, optimized distributed energy systems can reduce power loss by about 15 percent and improve the efficiency of traditional power systems. This not only reduces energy waste, but also reduces carbon emissions, which plays a positive role in sustainable energy development and environmental protection.

3.4. Application of smart grid technology

3.4.1. Smart grid technology

Smart grid technology is a power system innovation solution that combines sensor technology, high-speed communication technology (such as the Internet of Things and 5G), and advanced data analysis technology. Smart sensors can monitor the state of each link of the power system in real time, communication technology ensures the rapid transmission and sharing of these data, and data analysis technology provides intelligent decision support by processing these data. The Internet of Things technology has been extensively employed in the energy sector, and IDC forecasts that its investment in the energy industry will expand at an average yearly rate of 10.4 percent over the coming years, thus augmenting the power system's intelligence. The application of 5G technology provides the transmission speed while achieving a lower delay, which greatly improves the response speed of the power system.

3.4.2. Optimize the role of scheduling

(1) Real-time monitoring of energy flow. Operators can use smart grid technology to continuously monitor the real-time generation, transmission, and consumption of energy, allowing them to gain a comprehensive understanding of the current state of power systems. This real-time monitoring contributes to the reasonable allocation of power resources, avoid system overload, and improve the security and reliability of the power grid.

(2) Fault diagnosis and self-healing ability. Smart sensors can quickly capture the abnormal situation in the power system, identify the fault cause through data analysis, and help the operation and maintenance personnel to respond quickly. The self-healing ability enables the system to quickly switch to the standby line when the fault occurs, avoiding the extension of the power outage time. The American Electric Power Research Institute has reported that the utilization of

smart grid technology has drastically decreased the self-healing time of the system by more than 30 percent[5].

3.4.3. Impact of smart grid technology in real cases

Realizing the intelligent management of power systems, a California-based power company has taken advantage of the introduction of smart grid technology. By utilizing smart sensors to monitor electricity users' demands, they have been able to arrange electricity demand in an intelligent manner. This fine scheduling makes the operation of the power system more efficient, reducing energy waste and shortening the power outage time. With its application, smart grid technology reduces user outages by more than 50 percent and a 20 percent reduction in operating costs, according to the company.

4. Epilogue

The increasing need for energy and the impacts of global climate change have made the integration of renewable energy and conventional power systems a crucial subject in the current energy sector. However, this convergence faces the challenges of diversity, instability and uncertainty, including the diversity of energy sources, the volatility of renewable energy sources, and the impact of climate change and weather conditions. The integration of intelligent energy prediction and management, energy storage technology, optimization of distributed energy systems, and smart grid technology opens up fresh prospects for development, allowing for the combination of renewable energy and

traditional power systems to reduce the aforementioned effects. With the continuous innovation and improvement of technology, the energy field's various difficulties will be progressively resolved, and the amalgamation of renewable energy and conventional power systems will become more convenient and close. This combination will make a greater impact on the sustainable advancement of humanity and the optimistic future of the planet.

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